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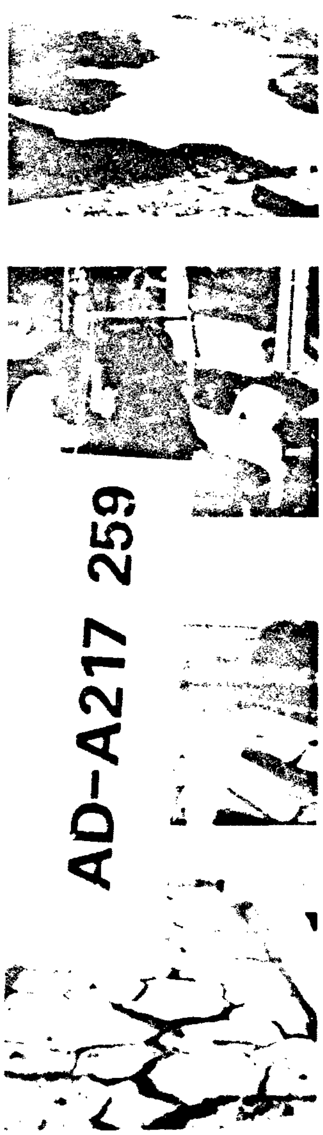

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TECHNICAL REPORT EL-88-15

NEW BEDFORD HARBOR SUPERFUND PROJECT, ACUSHNET RIVER ESTUARY ENGINEERING FEASIBILITY STUDY OF DREDGING AND DREDGED MATERIAL DISPOSAL ALTERNATIVES

Report 12

EXECUTIVE SUMMARY

by

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NEW BEDFORD HARBOR SUPERFUND PROJECT, ACUSHNET RIVER ESTUARY ENGINEERING FEASIBILITY STUDY OF DREDGING AND DREDGED MATERIAL DISPOSAL ALTERNATIVES

No. in Series	Report Title
1	Study Overview
2	Sediment and Contaminant Hydraulic Transport Investigations
3	Characterization and Elutriate Testing of Acushnet River Estuary Sediment
4	Surface Runoff Quality Evaluation for Confined Disposal
5	Evaluation of Leachate Quality
6	Laboratory Testing for Subaqueous Capping
7	Settling and Chemical Clarification Tests
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10	Evaluation of Dredging and Dredging Control Technologies
11	Evaluation of Conceptual Dredging and Disposal Alternatives
12	Executive Summary

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Sediments in New Bedford Harbor, Massachusetts, have been contaminated with polychlorinated biphenyl compounds and heavy metals. The high levels of contamination have resulted in the New Bedford site being placed on the National Priorities List of the Nation's worst hazardous waste sites. The US Army Corps of Engineers (USACE) has been working with the US Environmental Protection Agency (USEPA), Region 1, since 1986 in efforts to evaluate remedial action alternatives for this site.

The USEPA began investigating remedial alternatives for the site several years ago. Most remedial alternatives involve dredging the sediment in the estuary to remove the contamination from the aquatic environment. Because of its vast experience in dredging and disposing of sediment, the USACE was requested by the USEPA to perform an Engineering Feasibility Study (EFS) of Dredging and Dredged Material Disposal Alternatives. The purpose of the EFS

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18. SUBJECT TERMS (Continued).

Confined disposal facility	Dredging	Sediment
Contained aquatic disposal	Feasibility study	Sediment transport
Contaminant migration	Management strategy	Superfund
Disposal alternatives	New Bedford, MA	
Dredged material disposal	PCB	

19. ABSTRACT (Continued).

was to evaluate the engineering feasibility of dredging and selected disposal alternatives for removal and disposal of contaminated sediment from the New Bedford Superfund Site.

The technical approach for the EFS used field data collection, literature reviews, laboratory studies, and analytical and numerical modeling techniques to assess engineering feasibility and develop conceptual alternatives for dredging and dredged material disposal. This approach was built around the contaminant testing and controls presented in the USACE "Management Strategy for Disposal of Dredged Material." Technical and engineering issues addressed by the EFS included baseline mapping, geotechnical investigations, hydrodynamics, sediment resuspension and transport, contaminant releases to surface and ground water, dredged material confinement in disposal areas, effluent treatment, and cost estimates.

Results of the EFS are presented in a series of 12 reports. Reports 1-11 present detailed results of field investigations, laboratory studies, and engineering analyses. This report, the Executive Summary, highlights information from the first 11 reports and presents results of the EFS.

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PREFACE

This study was conducted as a part of the Acushnet River Estuary Engineering Feasibility Study (EFS) of Dredging and Dredged Material Disposal Alternatives. The US Army Corps of Engineers (USACE) performed the EFS for the US Environmental Protection Agency (USEPA), Region 1, as a component of the comprehensive USEPA Feasibility Study for the New Bedford Harbor Superfund Site, New Bedford, MA. This report, Report 12 of a series, was prepared by the US Army Engineer Waterways Experiment Station (WES) and the New England Division (NED), USACE. Coordination and management support was provided by the Omaha District, USACE, and dredging program coordination was provided by the Dredging Division, USACE. The study was conducted between August 1985 and July 1988.

Project manager for the USEPA was Mr. Frank Ciavattieri. The NED project managers were Messrs. Mark J. Otis and Alan Randall. Omaha District project managers were Messrs. Kevin Mayberry and William Bonneau. Project managers for the WES were Messrs. Norman R. Francingues, Jr., and Daniel E. Averett.

Technical contributions to the EFS were made by the following personnel from the Environmental Engineering Division (EED) and the Ecosystem Research and Simulation Division (ERSD) of the WES Environmental Laboratory (EL): Mr. Norman R. Francingues, Jr., Dr. Michael R. Palermo, Mr. Tommy E. Myers, Mr. Roy Wade, Mr. Richard A. Shafer, and Mr. Mark E. Zappi, EED; and Dr. James M. Brannon, Mr. Thomas C. Sturgis, Mr. John G. Skogerboe, Dr. Douglas Gunnison, Mr. Richard A. Price, and Mr. Dennis L. Brandon, ERSD. Also making significant technical contributions were Mr. Allen M. Teeter and Ms. Virginia R. Pankow of the Estuaries Division, Hydraulics Laboratory, WES, and Ms. Pamela B. Rubinoff, Coastal Engineering and Survey Section, Engineering Division, NED.

This report was prepared by Mr. Daniel E. Averett, Water Supply and Waste Treatment Group (WSWTG), EED, EL, WES, and Mr. Mark J. Otis, New Bedford Superfund Project Office, Operations Division, NED. Technical reviews of the report were provided by Dr. Michael R. Palermo and Dr. M. John Cullinane, EED. The report was edited by Ms. Jessica S. Ruff of the WES Information Technology Laboratory.

The study was conducted under the general supervision of Mr. Norman R. Francingues, Jr., Chief, WSWTG, Dr. Raymond L. Montgomery, Chief, EED, and Dr. John Harrison, Chief, EL; Mr. Vyto Andreliunas, NED; and Mr. David B. Mathis, Dredging Division, USACE.

Commander and Director of WES was COL Larry B. Fulton, EN. Technical Director was Dr. Robert W. Whalin.

This report should be cited as follows:

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CONTENTS

CONVERSION FACTORS, NON-SI TO SI (METRIC) UNITS OF MEASUREMENT

Non-SI units of measurement used in this report can be converted to SI (metric) units as follows:

Multiply	By	To Obtain
acres	4,046.873	square metres
cubic feet	0.2831685	cubic metres
feet	0.3048	metres
inches	2.54	centimetres
miles (US statute)	1.609347	kilometres
pounds (force) per square inch	6.894757	kilopascals
square miles	2.589998	square kilometres

NEW BEDFORD HARBOR SUPERFUND PROJECT, ACUSHNET RIVER ESTUARY
ENGINEERING FEASIBILITY STUDY OF DREDGING AND DREDGED MATERIAL DISPOSAL ALTERNATIVES

EXECUTIVE SUMMARY

PART I: INTRODUCTION

1. Industrial and municipal waste releases into the Acushnet River Estuary and harbor areas adjacent to New Bedford, MA, over a period of several decades contaminated the bottom sediments of these areas with organic chemicals, principally polychlorinated biphenyls (PCBs), and heavy metals. Concentrations of PCBs greater than 10,000 ppm have been detected in sediment in the Upper Estuary segment of the Acushnet River (US Environmental Protection Agency (USEPA) 1983, Weaver 1982). As a result of environmental studies conducted by the State of Massachusetts and the USEPA during the 1970s and early 1980s, in 1982 the harbor and estuary were added to the National Priorities List of the Nation's worst hazardous waste sites. Thus, the New Bedford site was designated a Federal Superfund site and became eligible for Federal cleanup funds.

2. The USEPA began work on a Superfund Feasibility Study to develop remedial action alternatives for the highly contaminated sediments in the Upper Estuary above the Coggeshall Street Bridge (Figure 1). In August 1984, the USEPA published its Draft Feasibility Study of remedial action alternatives for the Upper Acushnet River Estuary (NUS Corporation 1984). After receiving extensive comments on the proposed remedial action alternatives from other Federal, state, and local officials, potentially responsible parties, and individuals, the USEPA responded with a decision to conduct additional studies to better define available cleanup methods. Because dredging was associated with all of the removal alternatives, USEPA requested the Nation's dredging expert, the US Army Corps of Engineers (USACE), to conduct an Engineering Feasibility Study (EFS) of dredging and disposal alternatives. A major emphasis of the EFS was placed on evaluating the conceptual design of dredging and disposal alternatives, their implementability, and their potential for contaminant releases.

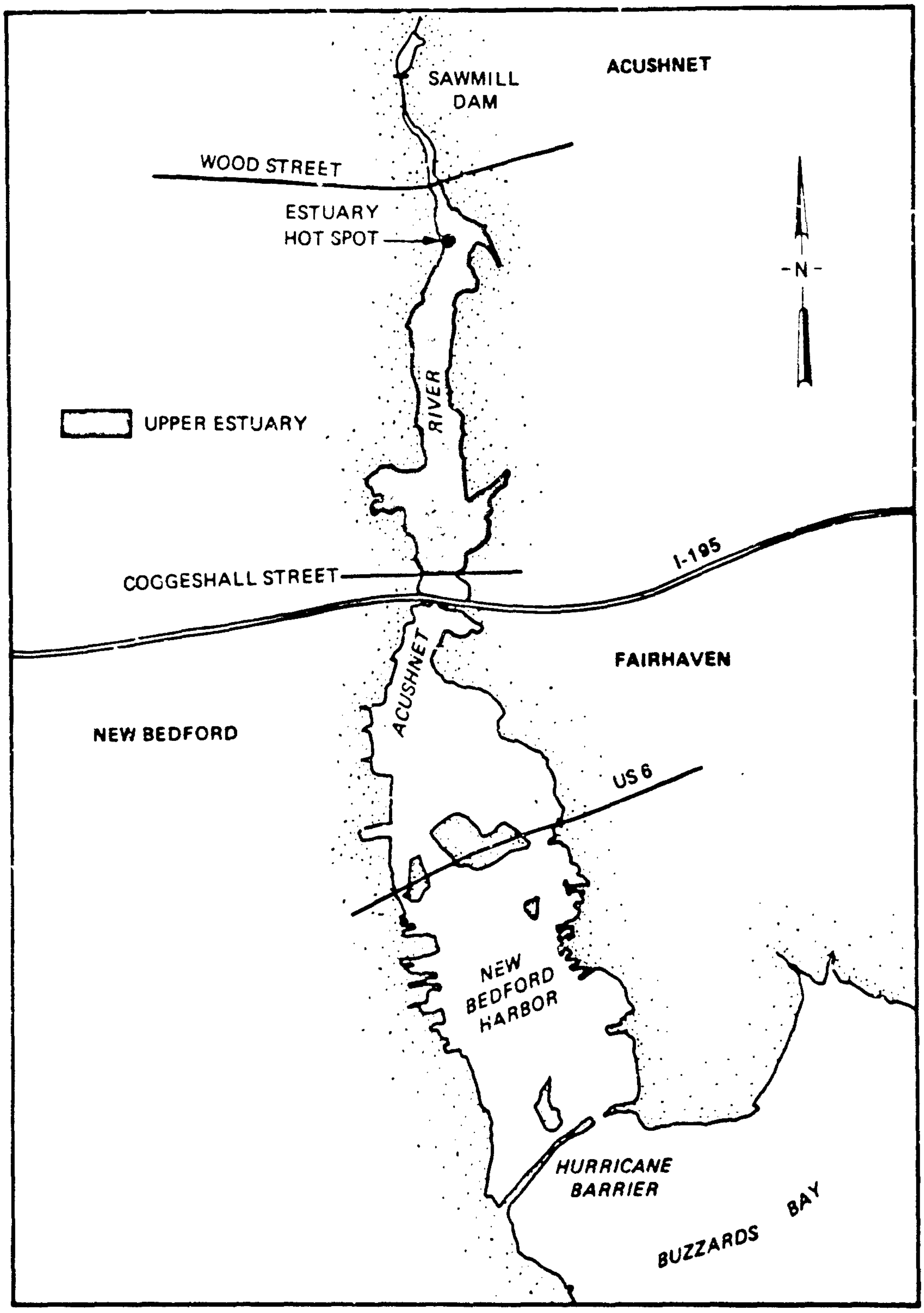

Figure 1. New Bedford Harbor and Acushnet River Estuary

3. The technical phase of the EFS was completed in March 1988. As part of Task 8 of the EFS, the results of the study were compiled in a series of 12 reports, listed below. (Complete bibliographic citations for these reports are given in Appendix A.)

a. Report 1, "Study Overview."

b. Report 2, "Sediment and Contaminant Hydraulic Transport Investigations."

c. Report 3, "Characterization and Elutriate Testing of Acushnet River Estuary Sediment."

d. Report 4, "Surface Runoff Quality Evaluation for Confined Disposal."

e. Report 5, "Evaluation of Leachate Quality."

f. Report 6, "Laboratory Testing for Subaqueous Capping."

g. Report 7, "Settling and Chemical Clarification Tests."

h. Report 8, "Compatibility of Liner Systems with New Bedford Harbor Dredged Material Contaminants."

i. Report 9, "Laboratory-Scale Application of Solidification/Stabilization Technology."

j. Report 10, "Evaluation of Dredging and Dredging Control Technologies."

k. Report 11, "Evaluation of Conceptual Dredging and Disposal Alternatives."

l. Report 12, "Executive Summary."

This report is Report 12 of the series. It summarizes results presented in detail in the previous 11 reports.

Background

Site description

4. New Bedford Harbor is located between the city of New Bedford on the west and the towns of Fairhaven and Acushnet on the east at the head of Buzzards Bay, Massachusetts (Figure 1). The Superfund Site includes the New Bedford Harbor, the Acushnet River Estuary, and a segment of Buzzards Bay immediately below the harbor, an area of 28 square miles* (Ciavattieri and Stockinger 1988). The Acushnet River drains a small basin of 18 square miles

* A table of factors for converting non-SI units of measurement to SI (metric) units is presented on page 4.

above the Sawmill Dam. Additional drainage enters the estuary and harbor areas through storm sewers and surface drainage. The Wood Street Bridge is the approximate upstream limit of tidal influence. The mean tide range for New Bedford Harbor is 3.7 ft, and the spring range is 4.6 ft.

5. Contaminant concentrations in sediment are greatest in the Upper Estuary portion of the site, defined as the area between Wood Street and the Coggeshall Street Bridge. A subarea of the Upper Estuary, where PCB concentrations are 1 to 2 orders of magnitude greater than the average for the Upper Estuary, has been designated as the Hot Spot. Remedial alternatives are being considered separately for the Upper Estuary, Lower Harbor and Bay, and Hot Spot. The Upper Estuary, the focus of this EFS, is estimated to be 187 acres at elevation mean low water plus 4 ft. Water depths in the Upper Estuary generally are less than 3 ft at mean low water except for the channel, where depth varies from 6 to 16 ft.

Remedial action alternatives for the Upper Estuary

6. The primary purpose of the USACE's EFS was to further evaluate the engineering feasibility of selected dredging and disposal alternatives for remediation of contaminated sediments in the Upper Estuary. Removal of contaminated sediments from the Upper Estuary requires the use of dredging technology. Once the sediment is removed from the estuary, a variety of options are available for containment, disposal, or treatment of the dredged material. E. C. Jordan Company is developing the comprehensive Feasibility Study that addresses all of these alternatives, as well as nonremoval alternatives.

7. The EFS evaluates two containment alternatives for the New Bedford site. The first alternative is dredging and placement of the dredged material in confined disposal facilities (CDFs) that can be constructed along the shoreline of the estuary. These are diked areas that initially provide for settling of dredged material solids and, later, for long-term containment of these solids and associated contaminants. Several control options may be integrated into the CDF design to minimize the loss of contaminants via the surface water, ground water, air, or biological uptake pathways and to prevent direct human contact with the contaminants.

8. The second alternative is dredging and placement of the dredged material in contained aquatic disposal (CAD) cells located beneath the Upper Estuary. The CAD alternative is a modification of capping technology where

the contaminated dredged material is isolated from the water column by a layer of clean sediment. Contained aquatic disposal is being considered for the Upper Estuary because the shallow water restricts the depth of capping material that can be placed on the in situ contaminated sediment. The concept of the CAD option is to excavate a series of cells or pits by dredging the estuary to depths of 6 to 15 ft, to place contaminated sediment in the bottom of the cells, and to cover the contaminated sediment layer with layer of clean sediment. A storage area along the shoreline is required for the material excavated from the first cell. Dredged material removed to form subsequent cells is placed directly into the CAD cell created by the previous dredging operation. Contaminated top layers of the Upper Estuary are first placed in the bottom of the cell, and the relatively clean sediment beneath the contaminated material in the estuary is placed on top of the contaminated material to provide the cap.

Objectives and Scope

9. The objectives addressed in the EFS were to

   a. Develop a baseline characterization of the Upper Estuary with the degree of detail needed to assess the engineering feasibility of the proposed dredging and disposal alternatives.

   b. Assess the magnitude and migration potential of contaminant releases due to resuspension of sediments during proposed dredging operations.

   c. Perform laboratory and bench-scale testing developed specifically for dredged material to gather technical data needed for predicting the behavior of the dredged sediments if placed in the disposal environments under consideration.

   d. Combine the technically feasible dredging and disposal technologies into implementable alternatives and provide concept design cost estimates for each implementable alternative.

10. The EFS scope included field data collection activities, literature reviews, laboratory and bench-scale studies, engineering and economic analyses, and analytical and numerical modeling techniques to assess engineering feasibility and develop conceptual alternatives. Laboratory and bench-scale testing protocols were selected from the suite of tests described in the USACE "Management Strategy for Disposal of Dredged Material" (Francingues et al. 1985). This strategy, based on worldwide experience in managing dredged material and on research by the USACE, USEPA, and others over the past decade,

provides a technically feasible and environmentally sound approach to the disposal of dredged material from Federal navigation projects. The Management Strategy is applicable to a wide variety of sediment types, including the most highly contaminated Superfund materials. Application of these protocols to New Bedford Harbor sediment allowed for site-specific evaluation and conceptual design of the CAD and CDF alternatives.

11. The EFS was managed and implemented under a program of seven technical tasks:

a. Baseline maps and controls.
b. Sediment characterization.
c. Geotechnical investigations.
d. Contaminant migration studies.
e. Composite sample collection.
f. Laboratory testing of the composite sample.
g. Conceptual design of dredging and disposal alternatives and estimates of costs.

Detailed descriptions of these tasks and the subordinate elements of each task are given in Report 1.

Pilot Study

12. Early in the course of the EFS, the USACE and the USEPA recognized the benefits of including a field evaluation of dredging and disposal alternatives to supplement the laboratory and modeling efforts of the EFS. A pilot-scale evaluation represents a sound engineering step between laboratory studies and final selection and design of a prototype system. It is particularly appropriate for evaluation of dredging technologies, which are difficult to simulate or model and whose performance is highly dependent on site-specific factors or conditions.

13. A pilot project was performed in the Upper Estuary during 1988 and early 1989. The project evaluated the effectiveness of three types of hydraulic dredges, a CDF, and a CAD cell. Data generated as a part of the EFS were used to design the components of the pilot project, to estimate contaminant releases to surface water and ground water during the pilot project, and to provide the basis for the monitoring and evaluation program for the project. Results of the Pilot Study are published separately from those of

the EFS (US Army Engineer Division (USAED), New England, in preparation), but preliminary information developed during implementation of the pilot supported the final stages of the EFS as conceptual alternatives were being developed. Generally, the pilot project supports the assumptions and procedures used in the EFS for evaluation of dredging and dredged material disposal for the Upper Estuary.

PART II: MAJOR FINDINGS

Site Characterization

Topography and bathymetry

14. A hydrographic survey of the Upper Estuary and topographic surveys of the Upper Estuary and potential disposal sites south of the Coggeshall Street Bridge were completed by the New England Division. These surveys were used to establish control points for locating sampling points for the sediment characterization program, to compute volumes of material to be dredged, to determine limitations to dredging operations due to site conditions, and to develop conceptual designs for disposal facilities.

15. The surface area of the Upper Estuary is 187 acres below the +4.0 ft mlw contour elevation. Distance between the Wood Street and Coggeshall Street bridges is 1.5 miles. A steep bank and numerous seawalls and bulkheads occupy much of the well-developed western shoreline. Top of bank elevation for this side of the estuary is approximately 6 ft above mlw. Consisting mostly of wetlands, the eastern shoreline is for the most part undeveloped. Steep banks along the shoreline indicate that the wetland is eroding. The top of bank elevation for this side is between elevations +3 and +4 ft mlw. An extensive area of mud flat occupies the northeastern section of the estuary.

16. The Upper Estuary channel near the Coggeshall Street Bridge is approximately 250 ft wide and 15 ft deep. It becomes progressively narrower and shallower going upstream (north) until it essentially disappears at a depth of 2 ft about 4,000 ft north of the bridge. Water depths in the northern 2,500 ft of the estuary are no more than 2 ft at mlw. Similar depths are found within 200 ft of the shoreline and within coves in the southern portion of the estuary.

Geotechnical

17. Both a seismic survey and a geotechnical investigation were conducted to provide additional information on the physical characteristics of the soil underlying the estuary. This information was important to accurately evaluate the technical feasibility and costs of constructing various types of disposal sites. The geotechnical investigation was performed in the fall of 1986 and included the execution of 14 in-water borings, 5 land borings,

8 in-water probes, and 2 land probes and the installation of 5 observation wells. Additional geotechnical studies were conducted in 1987 to develop design information for the Pilot Study.

18. Woodward-Clyde Consultants (1987) conducted the geotechnical investigation of the New Bedford Superfund site for the Corps of Engineers. Subsurface conditions within the estuary include a profile of clay, sandy clay to clayey sand, low to nonplastic silt, sandy silt to silty sand, gravelly sand, and sand. Subsurface materials encountered during the land borings were fill with rubble, clayey sand and gravel, silts, and sands. The top 3 to 5 ft of sediment was generally a black organic sandy silt to silt. Below this layer, the material was primarily sand with mixtures of gravel, clay, and silt. A layer of extremely weak material extending from the surface to 10 ft or more was found in some locations where disposal sites are proposed. These conditions require extraordinary construction measures to build and maintain a stable dike. Distance to bedrock was about 50 ft. Ground-water elevations for the monitoring wells installed along the shoreline ranged from 3 to 9 ft below the surface at the time of measurement.

19. Geotechnical information was also important in the selection and design of CAD cells in the Upper Estuary. The material to be excavated below the contaminated sediment in construction of CAD cells can be used as capping material for covering the contaminated sediment. The sediment becomes progressively coarser with depth, indicating that the capping material will be predominantly sand. An evaluation of side slope stability concluded that CAD cells could be constructed with stable side slopes of approximately 1 vertical to 3 horizontal.

Hydrodynamics and
sediment/chemical transport

20. The watershed for the Acushnet River at Sawmill Dam, located 2,300 ft above the Wood Street Bridge, includes an area of only 12,000 acres. Additional flow is contributed to the Upper Estuary downstream of the dam by a number of storm sewers draining the industrial and urban areas on the shores of the estuary. Mean annual freshwater inflow has been estimated as 32 cfs (Jason M. Cortell and Associates 1982). Actual discharge measurements reported in the literature range from 0.56 cfs minimum monthly flow to a peak flow of 500 cfs. Field measurements made on 3 days during the spring and summer of 1986 for this study were 8.8, 41, and 54 cfs.

21. The mean tide range for New Bedford Harbor is 3.7 ft, and the spring range is 4.6 ft. Currents in the Upper Estuary are greatest at the Coggeshall Street Bridge, which constricts the flow to a channel 110 ft wide and 19 ft deep. Currents upstream of the bridge are generally low. The shallow estuary was found to be vertically well mixed with little vertical circulation.

22. Concentrations of total suspended material (TSM) were generally below 10 mg/ℓ and increased in the upstream direction. Suspended materials were found to be generally migrating from Buzzards Bay upstream into the Upper Estuary. The rate of sediment transport measured at the Coggeshall Street Bridge was about 2,500 kg per tidal cycle. However, about two thirds of the TSM entering the Upper Estuary on the flood tide was flushed out on the next ebb tide for the conditions monitored. Tidal pumping was concluded to be the dominant transport mechanism for TSM (see Report 2).

23. WES field measurements of PCB flux for the Upper Estuary due to existing conditions indicated that PCBs escape the Upper Estuary at an average rate of 1.6 kg per tidal cycle. The USEPA (1983) made similar measurements which indicated an average PCB flux of 0.91 kg per tidal cycle. Transport of PCBs in a direction opposite to the flux of TSM is believed to be a result either of contamination of clean suspended sediment entering the Upper Estuary or of soluble releases in the Upper Estuary. The important point is that the Upper Estuary continues to contribute PCB contamination to downstream waters.

Sediment characteristics

24. A review of existing characterization data for sediment in the Upper Estuary revealed that additional chemical and physical data were necessary for EFS evaluation of dredging and dredged material disposal. One of the more important unknowns was the depth of sediment contaminated by PCBs and heavy metals. Physical characteristics were also inadequately described by previous studies. The sediment characterization program was also needed to select sediment characteristics and the areas to be sampled for preparation of large composite sediment samples that were subsequently tested for the EFS.

25. A sampling grid consisting of 150 cells, each 250 ft square, was established and correlated with the topographic survey data. A total of 168 sediment cores from 143 cells were collected in 3-in.-diam Plexiglas tubes to a depth of 6 ft or to refusal. Eighty percent of these cores were greater than 24 in. in length, and the average core length was 53 in. Twenty percent

of these cores, selected at random, were subsampled at one to three depths and analyzed for PCBs, arsenic, cadmium, chromium, copper, lead, mercury, nickel, zinc, oil and grease, grain size, Atterberg limits, specific gravity, moisture content, volatile soils, and cation exchange capacity. Results of this characterization program are reported by Condike (1986). An additional sampling effort was performed by NED in 1987 to determine spatial distribution of PCB contamination for the Hot Spot.

26. Physical characteristics of sediments in the Upper Estuary were evaluated from the standpoints of suitability for dredging and for disposal facilities. The top 3 to 5 ft of sediment was found generally to exhibit the same physical characteristics, i.e., a black organic sandy silt to silt. Approximately 43 percent of the material in this layer, on the average of the cores tested, was sand, and the average in situ water content was 111 percent. Sediment below this layer consisted primarily of sand with mixtures of gravel, clay, and silt. Material along the eastern shore was coarser than that found on the New Bedford side of the estuary.

27. Sediment PCB concentrations ranged from less than 2 mg/kg near the Coggeshall Street Bridge to 100,000 mg/kg for a sample collected from the area designated as the Hot Spot. The PCB concentrations were generally lower on the eastern side of the estuary. With the possible exception of the Hot Spot, contamination was limited to the top 2 ft of sediment, and the lower 1 ft was usually considerably cleaner than the top 1 ft. Heavy metal concentrations exhibited less spatial variability than PCB concentrations, but heavy metal contamination also appears to be confined to the top 2 ft of sediment. The metals present in the highest concentrations were zinc, copper, lead, and chromium (see Report 11).

28. Results from the sediment characterization program were used to select sites for collection of three composite samples tested during the EFS. A composite representing the contaminated sediment in the Upper Estuary was based on a PCB concentration representing the highest concentration for 90 percent of the cores tested. The target concentration was 1,100 mg/kg, and the actual composite concentration was 1,550 mg/kg (see Report 3). A sample of the less contaminated sediment, which may be placed as the top layer or cover of the CDF, was also collected for surface runoff testing (see Report 6). Finally, a sediment sample from the Hot Spot was collected for potential laboratory testing.

Contaminant Migration Studies

Approach

29. The purpose of EFS contaminant migration studies was to evaluate the quantity of suspended sediment and associated contaminants that would be expected to move out of the Upper Estuary during dredging and disposal operations. Two types of experiments were performed: (a) a series of laboratory and field tests to study the types of sediment material that may be released if disturbed by dredging, and the associated contaminant levels that could be released to the environment and (b) a series of experiments in a specially constructed laboratory water tunnel to determine parameters for known relationships between the flows (currents) in the estuary and the amount of sediment that would be eroded from the bottom or that would settle to the bottom of the estuary. Field data on tides, currents, and sediment transport were used to calibrate an estuarine hydrodynamic and sediment transport model.

Erosion/deposition tests

30. Laboratory tests on the settling, deposition, and erosion characteristics of the fine-grained component of Upper Estuary sediments identified three sediment fractions. One sediment fraction was by far the slowest to settle and deposit, and easiest to resuspend. This mobile fraction comprised 28 percent of the EFS composite sample and could vary from 1 to 60 percent at various sites in the Upper Estuary. Suspended sediment in this mobile fraction will escape beyond 100 m from a resuspension source such as a dredge or a CAD filling operation (see Report 2).

Numerical modeling

31. Numerical modeling was performed to calculate tidal currents and to predict the movements of sediments within and out of the Upper Estuary during dredging and disposal using schematic two-dimensional numerical modeling. Computer codes RMA-2V and RMA-4 of the TABS-2 numerical modeling system (Thomas and McAnally 1985) were used to model vertically averaged hydrodynamics and sediment transport, respectively. Sediment migration modeling was a two-step process, with hydrodynamic model calculations performed first and used to drive sediment transport calculations. Analyses of the sediment transport runs were then made to estimate the escape of resuspended material from the Upper Estuary.

Sediment transport estimates

32. The model provided escape probabilities for sediment resuspended by dredging and disposal operations occurring at three points in the Upper Estuary. Escape probabilities for the most mobile fraction ranged from 0.76 to 0.52 for the lower and upper release points in the Upper Estuary (see Report 2). Combining the escape probabilities with the fraction of in situ sediment that is mobile during resuspension yields an estimated range of 15 to 20 percent of the sediment resuspended at the source will escape through the Coggeshall Street Bridge. Estimates of suspended and dissolved contaminant concentrations were based on elutriate tests, and mass fluxes for contaminants were calculated (see Report 11). The model also indicated that deepening the Upper Estuary by dredging to remove contaminated sediment would not appreciably alter hydrodynamics of the estuary.

Dredging resuspension

33. Dredging resuspension rates for the EFS were based on literature reviews and field sampling at and around the box core dredging sites for collection of the EFS composite samples. The operation of the sampling vessel caused more resuspension than the box core dredging, indicating that control of vessel operations in the shallow waters in the Upper Estuary is important to controlling resuspension from a dredging operation. Overall resuspension rates were calculated to be 40 to 70 g per second. Evaluation of cutterhead and matchbox dredges during the Pilot Study indicated that these estimates for dredging resuspension were conservative, i.e., greater than actual (USAED, New England, in preparation).

CAD resuspension

34. Resuspension and release rate estimates used in this study suggested that releases from he CAD cells during filling would be a larger source of sediment resuspension than dredging or CDF effluent. Near-field dredge plume and CAD cell deposition models were applied to cleanup dredging scenarios. Results from the CAD cell model indicated that the fine resuspended material expelled from the slurry with the pore water will escape from the CAD cell. Experimentally determined erosion thresholds indicate that CAD cells should be sited in areas with relatively low current speeds (less than 0.4 fps) to avoid resuspension (see Reports 2 and 11).

Disposal Alternatives Testing

Approach

35. As was stated in Part I, New Bedford sediment was tested in accordance with recommendations of the USACE Management Strategy (Francingues et al. 1985). Use of the Management Strategy, where appropriate, has been adopted as Army policy (33 CFR 336) for dredging projects to supplement the review procedures and requirements in the Section 404(b)(1) guidelines (40 CFR 230) and the Ocean Dumping Criteria (40 CFR 220). It "represents the current state of knowledge in testing and interpretation of environmental effects and consequences in disposal of contaminated dredged material" (Federal Register, 26 April 1988). Application of the Management Strategy to a Superfund site such as New Bedford is a logical approach because it addresses many of the migration pathways that may be impacted during dredging and dredged material disposal.

36. Steps identified by the Management Strategy for evaluation of dredged material disposal alternatives are as follows:

- a. Conduct an initial evaluation to assess contamination potential.
- b. Select a potential disposal alternative.
- c. Identify potential problems associated with that alternative.
- d. Apply appropriate testing protocols.
- e. Assess the need for disposal restrictions.
- f. Select an implementation plan.
- g. Identify available control options.
- h Evaluate design considerations for technical and economic feasibility.
- i. Select appropriate control measures.

Steps a and b were accomplished during investigations of the New Bedford site under the Superfund program. The EFS began with step c and proceeded through the remainder of the process.

37. Potential contaminant problems associated with the CDF alternatives being considered for this project were identified as loss of contaminants through the surface water, ground water, and atmospheric pathways. These losses may occur as a result of effluent from the CDF during dredging operations, surface runoff from the CDF, leachate moving through the dikes and/or

the foundation of the CDF, and volatilization from the CDF. Modified elutriate, leachate, and surface runoff tests and volatilization studies were applied to assess the contaminant concentrations for each of these sources. The limited number of available CDF sites did not allow selection of optimum site conditions for disposal. Therefore, evaluation of potential implementation plans was directed at the benefits of control measures that could be applied to the existing sites. Plant and animal uptake are other important pathways for the CDF; however, testing was not performed for these pathways under the assumption that control measures for the CDFs would include a cap to isolate the contaminants from plant and animal life.

38. Control options considered in the evaluation of CDFs were effluent treatment, capping, installation of impermeable liners, solidification of the dredged material, and operational controls. Laboratory testing related to CDF design and effluent treatment included column settling tests, consolidation tests, chemical clarification tests, and carbon adsorption isotherms. Solidification was evaluated by performing batch leach tests and unconfined compressive strength tests on the solidified products (see Report 9). Options for capping or lining the CDFs, including choices of materials, were assessed on the basis of information in the literature.

39. The CAD alternative is an option for controlled open-water disposal of contaminated sediment. The EFS focused on water column impacts during placement of the contaminated sediment and after capping the contaminated sediment with clean material. Water column impacts were evaluated using elutriate tests. Testing of capping effectiveness addressed contaminant migration through a clean capping material and provided design information for the CAD alternative. Literature reviews provided information for determining the capping thickness necessary to avoid breaching of the cap by burrowing organisms.

Contaminant mobility tests

40. A summary of laboratory data for contaminant mobility testing of New Bedford sediment is presented as Table 1. Results of elutriate, leachate, and surface runoff tests are shown for evaluations for composite, Hot Spot, and low-level PCB sediment. Analyses for PCB Aroclors, cadmium, copper, and lead are given in Table 1. The EFS reports that are referenced include additional parameters and detailed discussion of the data.

Table 1

Summary of Laboratory Contaminant Mobility Test Data

Sediment Sample	EFS Report No.	Test	Contaminant Concentration A1242 mg/ℓ	A1254 mg/ℓ	Cd mg/ℓ	Cu mg/ℓ	Pb mg/ℓ
Composite	3	Standard elutriate					
		Total	0.13	0.049	--	--	--
		Dissolved	0.082	0.029	--	--	--
	3	Modified elutriate					
		Total	0.14	0.074	--	0.079	0.026
		Dissolved	0.068	0.036	--	0.057	0.011
	5	Leach (anaerobic)					
		Batch (Step 1)	0.18	0.083	0.0002	0.008	0.009
		Permeameter (maximum)	0.012	0.0086	0.0029	0.017	0.010
Hot Spot	3	Standard elutriate					
		Total	2.0	1.1	--	0.12	--
		Dissolved	0.46	0.12	--	0.0067	--
	3	Modified elutriate					
		Total	0.92	0.28	0.0059	0.18	--
		Dissolved	0.34	0.13	0.0025	0.017	--
	9	Leach (maximum concentration)					
		Batch	0.43	0.29	<0.0001	0.01	0.013
		Permeameter	--	--	-	--	--
Low-level	4	Surface runoff					
Wet, un-oxidized		Total	0.025	0.096	0.15	7.8	1.0
		Dissolved	0.0026	0.0014	0.004	0.013	0.003
Dry, oxidized	4	Total	0.022	0.0088	0.025	0.42	0.34
		Dissolved	0.0008	0.0005	0.029	0.10	0.014

41. Elutriate tests. A comparison of the elutriate data to Federal water quality criteria indicated that the criteria for PCB, copper, and lead would be exceeded in the immediate vicinity of the CDF discharge or the discharge of dredged material into a CAD cell. However, consideration of a mixing zone will dilute the concentrations in the estuary and should reduce the concern for heavy metal releases. Since PCB concentrations exceed the criteria under existing conditions, the PCB criteria cannot be met during remedial actions. An assessment of the benefits of effluent treatment for PCB removal was based on the total mass PCBs released for the CDF alternative. Hot Spot elutriate PCB concentrations were of such magnitude that CDF effluent treatment during disposal of Hot Spot sediment may be justified.

42. Leach tests. State-of-the-art batch and column leach tests were conducted on anaerobic and aerobic New Bedford sediment. Sequential batch leach tests conducted by the US Army Engineer Waterways Experiment Station (WES) produced desorption isotherms from which distribution coefficients can be calculated. Column leach tests were conducted in divided-flow permeameters. Desorption of PCBs and metals from New Bedford Harbor sediment did not follow classical partitioning theory. Anaerobic distilled water PCB desorption isotherms showed nonconstant partitioning (negative slopes) to a turning point, after which PCB desorption tended to follow classical, linear partitioning (see Report 5).

43. Sequential leaching with saline water showed that the nonconstant partitioning portion of the PCB desorption isotherms was associated with changing conductivity, and hence salinity. Conductivity-distribution coefficient correlations provided reliable estimates of PCB concentrations as saline pore water was displaced by infiltration of distilled water. The shape of observed PCB elution curves from anaerobic permeameter leach tests agreed with the shape of elution curves predicted from batch desorption isotherms, although permeameter concentrations were generally lower than batch concentrations. Sequential batch leach tests for aerobic sediment indicated that large quantities of nickel and zinc will be present in leachate from a sediment that is allowed to dry and become aerobic (Report 5).

44. Values for leachate quality shown in Table 1 for the composite sediment were used for subsequent evaluations of potential contaminant losses associated with leachate from a CDF. Implications of the results of the leach tests for design and management of CDFs to minimize contaminant mobility are

that the freshwater washout of salinity from dredged material should be avoided and the sediment should be maintained in an anaerobic state. Installation of an impermeable cap over New Bedford dredged material should be included as a control measure for the CDF alternative.

45. Surface runoff tests. Surface runoff tests were performed on a sediment sample with a PCB total Aroclor concentration of 104 mg/kg (see Report 4). This Upper Estuary sediment collected just upstream of the Coggeshall Street Bridge is representative of low-level PCB concentrations for the Upper Estuary. Dredging operations could be planned to place this material on top of the more contaminated sediment from the Upper Estuary in a CDF. These tests were conducted by applying water from a rainfall simulator onto a lysimeter containing the sediment. One series of tests was performed on the wet sediment immediately after placing the material in the lysimeter. The second series of tests was performed after the sediment had dried for 6 months and become oxidized. Selected runoff concentrations are shown in Table 1.

46. Potential surface runoff water quality problems during the wet, unoxidized period of a CDF would be associated primarily with the suspended solids in the runoff. During these conditions, technologies to remove suspended solids would remove 90 to 99 percent of the contaminants in the surface runoff. Dissolved copper is the only contaminant measured in filtered samples that exceeded Federal acute water quality criteria. After 6 months of drying, filtered concentrations represented a more significant fraction of the total contaminant concentrations. Copper and zinc for filtered samples equaled or exceeded acute water quality criteria. Capping the CDF with clean dredged material or soil before the contaminated dredged material dries is an appropriate control measure for CDFs to minimize contaminant releases during surface runoff.

47. Volatilization evaluation. A concern for volatilization of PCBs during dredging and disposal was identified in the course of the EFS. An evaluation of theoretical models for evaluation of volatile emissions to air during dredging and dredged material disposal was performed by Thibodeaux (1989). Rate equations based on chemical vapor equilibrium concepts and transport phenomena fundamentals were developed to predict chemical flux from four emission locales: dredged material relocation, exposed dredged material, ponded dredged material, and vegetation-covered dredged material. Emission rates are primarily dependent on the chemical concentration at the source, the

surface area of the source, and the degree to which the dredged material is in direct contact with the air. The ranking of the four locales for highest to lowest emission rates is exposed dredged material, ponded dredged material where the concentration of suspended solids in the overlying water column is high, bed sediment or dredged material below a quiescent water column, and the vegetation-covered dredged material locale. A limited-scope laboratory study using a flux chamber produced emission rates from New Bedford sediment that generally supported the theoretical models. The implication of the volatilization evaluation for management of CDFs is that wet or damp dredged material should not be exposed to air. Therefore, contaminated dredged material should be capped with clean dredged material before removing all of the supernatant from the CDF. Placement of the dredged material slurry below the water surface will also reduce volatile losses.

CDF design tests

48. Settling tests. The most important laboratory data for design of CDFs are derived from laboratory column settling tests prescribed by Engineer Manual 1110-2-5027 (USACE 1987). Results from these tests are used to estimate the CDF storage volume required to initially place hydraulically dredged sediment in a CDF and to estimate the CDF effluent suspended solids concentration during hydraulic dredging. New Bedford sediment settling behavior was found to be similar to other marine sediments tested at WES. For the dredging/CDF scenarios evaluated, dredged material volume will increase by about 40 percent compared with in situ sediment volume. Laboratory effluent suspended solids concentration, after 24 hr of settling, was about 150 mg/ℓ (see Report 7). Consolidation tests were also performed to predict the long-term settling characteristics of New Bedford dredged material. These tests indicated that the CDF material will dewater and consolidate over a period of approximately 3 to 5 years and approach its in situ sediment density.

49. Chemical clarification tests. Laboratory jar tests were performed to evaluate the effectiveness of using organic polymers as an aid in removing suspended solids and associated contaminants from CDF effluent. Polymers from a number of manufacturers were tested. Low-viscosity, cationic emulsion polymers were the most effective, economical, and simplest to use. As much as 82 percent suspended solids removal from simulated effluent was achieved by flocculation and settling in the laboratory tests (see Report 7).

50. Treatability studies. Carbon isotherm studies were conducted on simulated CDF effluent to assess the effectiveness of this technology in removing PCBs from CDF effluent or leachate. More than 95-percent removal of dissolved PCB was achieved at a carbon concentration of 200 mg/ℓ. For this carbon dosage, the mass of PCB removed per mass of activated carbon was 0.04 mg PCB removed per gram carbon, and the residual PCB concentration was <0.0004 mg/ℓ. Additional carbon studies were performed in conjunction with the Pilot Study. Removal of suspended and colloidal PCB materials prior to carbon adsorption is essential to achieving a high-quality effluent. The Pilot Study also evaluated PCB destruction by an ultraviolet light and hydrogen peroxide treatment system. This technology demonstrated effective destruction of PCBs on the order of 80 percent for total PCBs.

51. Solidification/stabilization (S/S) studies. Laboratory studies were also conducted to evaluate the technical feasibility of applying S/S technologies to New Bedford sediment (see Report 9). The three S/S processes selected for evaluation were portland cement, portland cement with Firmix proprietary additive, and Silicate Technology Corporation's proprietary process. Effectiveness of these processes in reducing contaminant mobility was evaluated using unconfined compressive strength (UCS) tests and the WES sequential batch leach tests. The UCS data showed that New Bedford sediment can be converted to a hardened mass with UCS values ranging from 20 to 481 psi. The WES sequential batch leach tests using distilled-deionized water showed that cadmium and zinc releases were substantially reduced by the S/S processes and that PCB leaching was reduced by factors of 10 to 100. However, copper and nickel mobility appeared to be increased by treating the sediment with the S/S processes. The conversion of dredged material from a plastic state to a solid monolith reduces the accessibility of water to the contaminants and provides additional control for leaching of contaminants from the solidified/stabilized material.

52. Liner evaluations. Synthetic materials are commonly used for containing leachate in storage areas for highly contaminated materials. A concern in using these materials is their compatibility with contaminants in the wastes. Available literature and data pertaining to chemical compatibility of synthetic and natural liners with both organic and inorganic contaminants were reviewed (see Report 8). Although compatibility testing with various liner materials and leachate directly from New Bedford sediment has not been

performed, testing with mixtures of similar and higher contaminant concentrations has indicated no significant compatibility problems. Lining experience has shown that quality control during liner installation and long-term reliability and durability of synthetic and natural liners may be of more concern than liner compatibility.

Capping effectiveness testing

53. The CAD alternative involves subaqueous capping of contaminated dredged material with clean sediment. A cap thickness is selected to prevent diffusion or advection of the contaminants to the overlying water column and to prevent breaching of the cap by burrowing aquatic organisms. Small-scale laboratory tests were used to determine the minimum cap thickness necessary to prevent chemical flux (see Report 6). The tests demonstrated that a 35-cm cap effectively isolated the contaminated sediment. Based on a review of the literature and discussions with local biologists, an additional 20 cm of cap thickness was recommended to prevent burrowing organisms from having access to the contaminants. The total of 55 cm is the minimum placed thickness of clean material. Additional material is required to ensure effective coverage with the design thickness over the entire CAD area, to protect against scouring by hydrodynamic forces, and to allow for long-term consolidation of the contaminated and clean dredged material.

Evaluation of Dredging Technologies

54. Most remedial action alternatives for the New Bedford Superfund Site involve removal of the contaminated sediment. Because the estuary is a large, dynamic body of water with tidal fluctuations, freshwater inflow, and other climatic influences, the logical technology for sediment removal is dredging. The EFS evaluated dredging equipment and dredging control technologies for application to the New Bedford site. Both mechanical and hydraulic dredges were considered. The evaluation of control technologies addressed operational controls for dredges, procedures for implementing a dredging operation, and control measures to contain sediment resuspended by dredging operations.

Dredging requirements

55. Dredging the Upper Estuary for remediation of contaminated sediment requires removal of a minimum of the upper 2 ft of sediment. Because of

limited CDF volume and the cost of treating or otherwise disposing of contaminated dredged material, an important objective for the dredging task is to remove the contaminated layer without excessive overcutting, which would produce a greater dredged material volume. A second objective is to minimize the amount of resuspension and associated contaminant release during dredging. Contaminants released to the water column at the point of dredging and transported beyond the immediate vicinity of the dredging operation are at that point very mobile and difficult to control.

Factors in equipment selection

56. The following factors were considered in the review and ranking of dredged equipment for the Upper Estuary:

a. Sediment resuspension. Equipment that minimizes sediment resuspension and associated contaminant release at the point of dredging are rated most favorably.

b. Cleanup precision. The equipment should be capable of removing 1-ft layers of sediment without excessive mixing of the contaminated material with the underlying cleaner sediment.

c. Availability. Equipment selected for the project should be readily available in the United States.

d. Safety. Safety of the dredging/construction personnel and the surrounding populace is an important consideration.

e. Maneuverability. Equipment should be capable of maneuvering in the shallow water of the Upper Estuary with minimum requirements for work boats, cables, etc., which potentially resuspend sediment.

f. Cost and production. Completion of the project in a timely manner and at a reasonable cost is considered.

g. Flexibility. Ability of a dredge to change operational conditions to accommodate changes in sediment type, water depth, and disposal requirements is advantageous.

h. Compatibility with disposal options. Equipment must be compatible with the transport and placement of material at the disposal site.

i. Draft. Because of shallow water in the Upper Estuary, dredges should be designed to have a maximum draft of 2 ft.

j. Access. Equipment must be able to pass through the 8-ft vertical clearance of the Coggeshall Street Bridge or must have the capability to be assembled and launched upstream of the bridge.

Dredging equipment
and techniques considered

57. Mechanical dredging equipment, such as clamshell dredges, dipper dredges, draglines, and backhoes, offers the advantage of removing the sediment at near its in situ density since a minimum amount of site water is retained in the bucket with the dredged material. This advantage benefits disposal operations because less volume is required for initial storage, and less effluent, potentially requiring treatment, is produced. On the other hand, the operating characteristics of mechanical dredges produce low ratings for many of the factors above, including sediment resuspension, cleanup precision, cost, and production. Mechanical dredges are not recommended as the primary removal technology for the Upper Estuary. However, mechanical dredges will be required to remove sediment along the well-developed western shore, where construction debris and rubble have accumulated over the years and hydraulic dredging is not feasible. This material can be removed with mechanical dredges working from the shore.

58. Nonmechanical dredges include hydraulic, pneumatic, and specialty dredges. Hydraulic dredges include cutterhead, dustpan, sidecast, and hopper dredges. Because of its efficiency and versatility, the cutterhead dredge is the most commonly used dredge in the United States. It was rated highly for its safety, cost, production, flexibility, compatibility with CDF and CAD options, draft, and access. The Pilot Study demonstrated that the cutterhead was effective with regard to cleanup precision and minimizing sediment resuspension.

59. The principal pneumatic dredge described in the literature is the PNEUMA pump. It is inappropriate for the Upper Estuary because its operating principle depends on a pressure differential created by the hydrostatic pressure of water on the outside of the pump. Shallow water in the Upper Estuary would not produce adequate pressure to make the pump work.

60. Specialty dredges include the Japanese-designed Oozer dredge, Clean-up dredge, and Refresher system; the Dutch-designed Matchbox dredge; and the US-built Waterless dredge, horizontal auger dredges, Delta dredge, Bucket Wheel dredge, and Jet pump. Japanese dredges were not ranked highly because of their limited availability in the United States. The Matchbox was retained because it is available in the United States and rates highly for a number of factors, including cleanup precision and sediment resuspension. Horizontal

auger dredges were also rated highly for most of the equipment selection factors.

61. The cutterhead, Matchbox, and horizontal auger dredges were selected for evaluation in the New Bedford Superfund Pilot Study. Results of the Pilot Study are reported in USAED, New England (in preparation). Generally, the cutterhead and the Matchbox were more effective in minimizing resuspension, compared with the horizontal auger dredge tested. All three dredges demonstrated acceptable cleanup precision and were able to operate successfully in the site conditions of the Upper Estuary.

Dredging controls

62. Operational procedures were recommended for effective cleanup precision and for minimizing or containing resuspended sediment. Two dredging passes, each removing a 1-ft layer, and accurate horizontal positioning will ensure that contaminated sediment is removed. Operational characteristics for the dredge must be tailored to the dredge type selected. Specific operational controls are discussed in Report 10. A submerged diffuser should be considered for controlled placement of dredged material in a CDF or a CAD site. Barriers, such as silt curtains, may contain suspended sediment where quiescent conditions can be maintained, but are difficult to maintain and have limited effectiveness in areas with strong current or tidal action.

Evaluation of the CDF Alternative

CDF design options

63. An implementation plan for the CDF alternative for the Upper Estuary is limited by the availability of suitable CDF sites. Six potential sites, as shown in Figure 2, were considered in the EFS evaluation of the CDF alternative. Sites 6 and 12 are upland sites; the remaining sites require dike construction within the estuary. Choices in the sequence selected for filling these sites and a variety of control measures applicable to these sites yield a number of conceptual design options for the CDF alternative. Control measures considered include liners, effluent treatment, leachate collection and treatment, and covers or caps. The CDF options evaluated in detail are listed in Table 2.

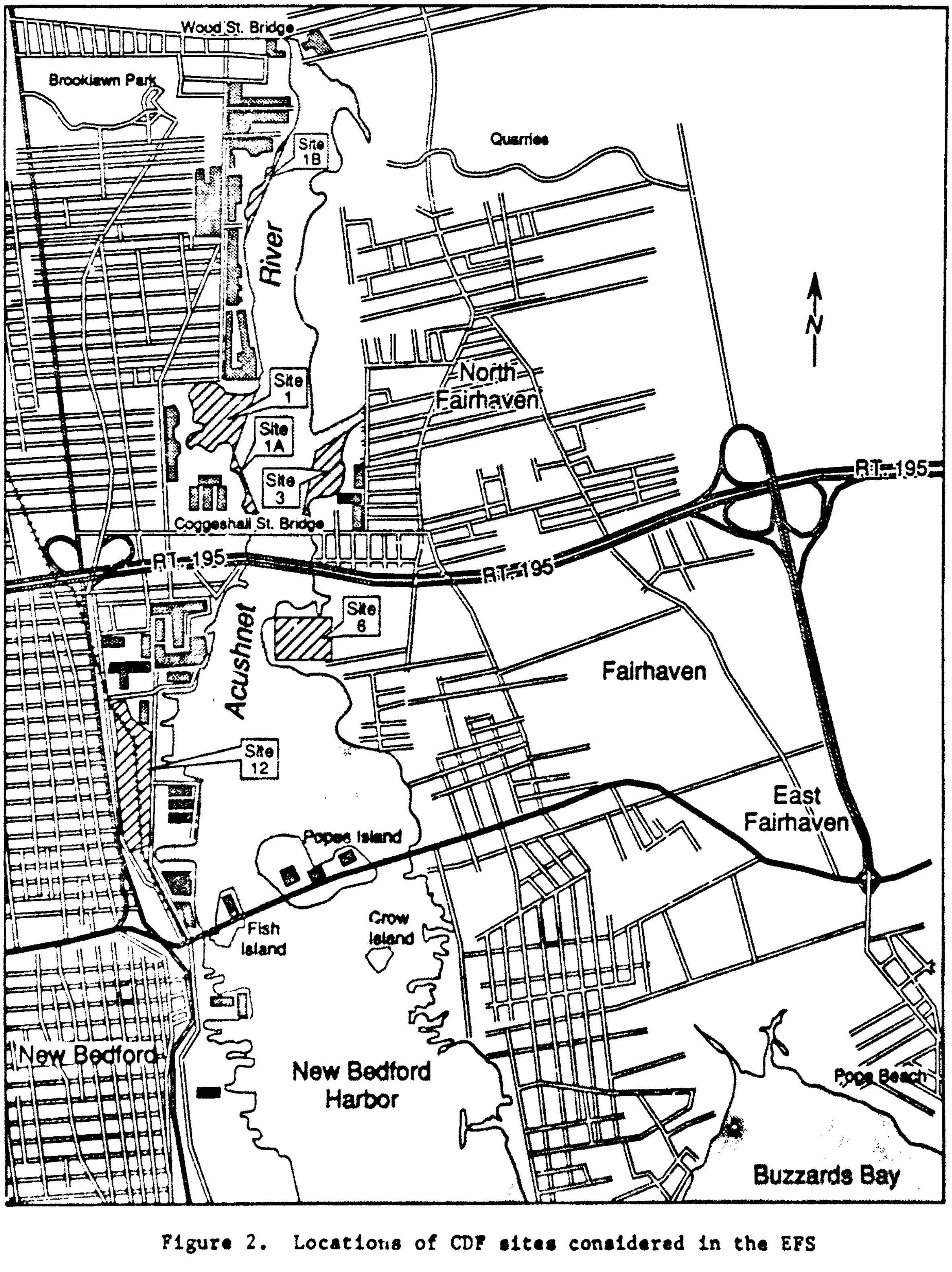

Figure 2. Locations of CDF sites considered in the EFS

Table 2

CDF Options with Additional Control Technologies

Option	Option/Control Combinations
CDF A1	CDFs 1, 1B, 3, and 12 + chemical clarification + surface cover
CDF A2	CDFs 1, 1B, 3, and 12 + chemical clarification + filtration + surface cover
CDF A3	CDFs 1, 1B, 3, and 12 + chemical clarification + filtration + carbon adsorption + surface cover
CDF B1	CDFs 1, 1B, 3, and 12 + chemical clarification + surface cover
CDF B2	CDFs 1, 1B, 3, and 12 + chemical clarification + filtration + surface cover
CDF B3	CDFs 1, 1B, 3, and 12 + chemical clarification + filtration + carbon adsorption + surface cover
CDF C	CDFs 1, 3, 6, and 12 + chemical clarification + filtration + liner/leachate collection + carbon adsorption + surface cover
CDF D	CDFs 1, 1B, 3, 6, and 12 + chemical clarification + filtration + liner/leachate collection + carbon adsorption + surface cover

Evaluation procedures

64. CDF design options were evaluated for engineering feasibility by assessing the implementability, technical effectiveness, and cost of each option. Disposal alternatives testing and contaminant migration analysis provided the data necessary for conceptual design and assessment of technical effectiveness. Implementability addresses the technical feasibility of constructing or operating the design option under site-specific conditions and the availability of disposal sites, equipment, materials, and/or conditions that may be necessary to implement the design option. Technical effectiveness is evaluated in terms of contaminant containment (short- and long-term) for all environmental pathways. Cost includes capital as well as operation and maintenance costs.

Rating of CDF design options

65. A summary of the ratings for the CDF design options is shown as Table 3. Short-term effectiveness was based on contaminant release estimates

Table 3

Evaluation of CDF Alternative - Summary

Design Option	Short-Term Effectiveness Rating	Long-Term Effectiveness Rating	Mobility Reduction Rating	Implementability Rating	Present Worth Cost ($000)
CDF A1	Moderate	Low	Moderate	High	30,303
CDF A2	Moderate	Low	Moderate	High	33,358
CDF A3	High	Low	Moderate	High	37,395
CDF B1	Moderate	Low	Moderate	High	30,674
CDF B2	Moderate	Low	Moderate	High	33,728
CDF B3	High	Low	Moderate	High	37,766
CDF C	High	Moderate	Moderate	High	41,343
CDF D	High	High	Moderate	Low	64,981

during the time period that dredging is occurring and for the time necessary to remove free water from the surface of the site. It includes water column releases at the dredgehead and CDF effluent. Options A3, B3, C, and D are rated highest because they employ effluent treatment for removal of dissolved PCBs. Long-term effectiveness ratings, which are based on the potential for contaminants to leach from the site, are low for those options without liners and leachate collection, i.e., A, B, and C. However, the reduction in contaminant release afforded by lining all of the CDF sites is less than 5 percent improvement compared with unlined option A3. Implementability ratings for all CDF options are high except for option D, which involves lining both upland and in-water CDFs. Lining the in-water CDFs will require extraordinary construction procedures and, even with careful installation, long-term reliability of the liner is questionable. Cost estimates for the design options for the CDF and CAD alternatives range from $30 million to $65 million (Table 3). Present worth cost estimates in going from option A1 to option C increases by about 30 percent; whereas, cost for the additional control provided by option D is more than 50 percent greater than option C.

Evaluation of the CAD Alternative

CAD design options

66. Implementation plans for the CAD alternative include use of an area of the Upper Estuary highlighted in Figure 3 and use of CDFs in the Upper Estuary. The area suitable for CAD construction, which was delineated using results of sediment erosion/deposition testing and numerical hydrodynamic modeling, is a low-energy depositional area where tidal currents allow placement of contaminated dredged material and clean capping material without excessive erosion and transport of dredged material solids. The CDFs are necessary to store contaminated material dredged from the CAD cell area, to store the initial clean material that must be removed to provide adequate depth for the CAD cell, and to temporarily store clean sediment to complete capping of the CAD site.

67. Two conceptual design options, labeled as CAD A and CAD B, were determined to be feasible. CAD option A involves placing the more contaminated materials from the northern half of the Upper Estuary into CDFs 1, 1A, and 3. These CDFs will be capped and remain as permanent disposal sites. Contaminated dredged material from the lower half of the Upper Estuary would be contained in the CAD cell. CAD option B involves placing the more contaminated material into permanent CDFs 1 and 1A. Contaminated material from near the Wood Street Bridge and from the lower half of the Upper Estuary would be placed in the CAD cell. Controls for the CAD options are listed in Table 4 and include effluent treatment technologies for CAD option A and surface covers for both A and B. Leachate controls were not considered for the CAD alternative.

68. The CAD cell depths for option A extend down to 10 ft and for option B, down to 15 ft. A geotechnical analysis determined that stable side slopes for the CAD cells were 3 horizontal to 1 vertical. The cells were sized to allow placement of a 4-ft cap of clean dredged material, so that even with long-term consolidation and initial mixing of the clean and contaminated material, the minimum recommended clean cap thickness of 2 to 3 ft could be reliably maintained. The submerged diffuser is recommended for placement of dredged material in the cells to minimize turbulence within the cell, to promote rapid settling of the dredged material slurry, and to avoid excessive mixing of the clean cap with the contaminated material.

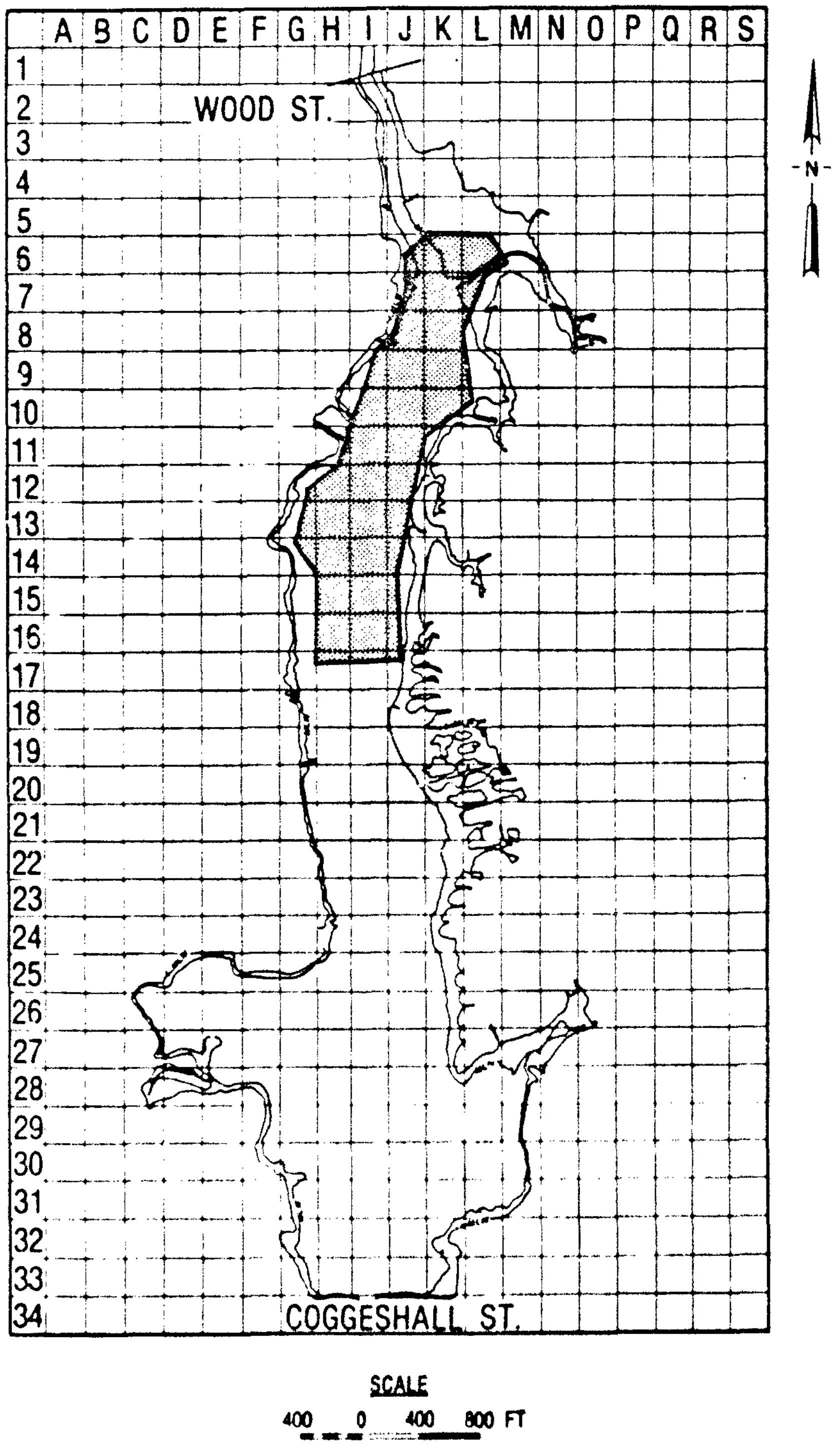

Figure 3. Area selected for CAD construction

Table 4

CAD Options with Additional Control Technologies

Option	Option/Control Combinations
CAD A1	CAD option A, including CDFs* 1, 1A, and 3 with CDF effluent treatment (chemical clarification) + CDF surface cover
CAD A2	CAD option A, including CDFs 1, 1A, and 3 with CDF effluent treatment (chemical clarification + filtration) + CDF surface cover
CAD A3	CAD option A, including CDFs 1, 1A, and 3 with CDF effluent treatment (chemical clarification + filtration + carbon adsorption) + CDF surface cover
CAD B	CAD option B, including CDFs 1 and 1A with effluent treatment (chemical clarification) + CDF surface cover

* CDFs listed in this table are permanent CDFs. Both options require additional CDF capacity for temporary storage of clean material.

Rating of CAD design options

69. The same evaluation factors used to rate the CDF design options were applied to the CAD options. A summary of the ratings thus obtained is presented as Table 5. The short-term effectiveness of the CAD options was rated lower than that of the CDFs because of the contaminant releases to the water column during placement of contaminated material in the CAD cells.

Table 5

Evaluation of CAD Alternative - Summary

Design Option	Short-Term Effectiveness Rating	Long-Term Effectiveness Rating	Mobility Reduction Rating	Implementability Rating	Present Worth Cost ($000)
CAD A1	Low	Moderate	Moderate	Moderate	36,105
CAD A2	Low	Moderate	Moderate	Moderate	39,001
CAD A3	Low	Moderate	Moderate	Moderate	42,670
CAD B	Low	Moderate	Moderate	Moderate	37,374

Long-term effectiveness of the CAD option was rated as moderate because contaminant containment within the geochemically stable underwater environment should be improved compared with CDFs. An advantage of the CAD options compared with options for the CDF alternative is that all of the contaminated sediment is handled and disposed of upstream of the Coggeshall Street Bridge. The CDFs used for CAD material below the bridge are for temporary storage of clean material. Implementability of the CAD option has been demonstrated at other sites and was successfully demonstrated for the Upper Estuary during the Pilot Study. Costs of the CAD alternative are similar to the CDF options with the major expenditures going for construction of the CDFs. Since the CAD options require fewer permanent CDFs and since land costs are not included in the costs presented, CAD options may actually be less expensive than CDF options.

PART III: CONCLUSIONS

70. The USACE "Management Strategy" outlines a framework for testing of contaminated sediment and evaluation of controls for dredging and dredged material disposal that is appropriate for evaluation of remedial actions for a Superfund site. Testing protocols developed for dredged material provide data to develop preliminary designs for CDFs and CAD facilities and to comparatively analyze contaminant mobility through important environmental pathways for various design options.

71. Laboratory testing protocols were effectively complemented by numerical hydrodynamic and sediment transport modeling to assess transport of sediment resuspended or released during dredging and disposal operations for a number of dredging scenarios. Sediment erosion/deposition tests identified sediment characteristics important to defining hydrodynamic conditions suitable for location of CAD cells.

72. Important site characterization data were essential to the evaluation of dredging and dredged material disposal alternatives. The spatial distribution of contaminants and physical characteristics of the sediment dictated dredging scenarios and affected design of disposal facilities. Geotechnical, topographic, and bathymetric data were necessary for adequate evaluation of dredging technologies and for design of CDFs and CAD cells.

73. The decision to plan and implement a Pilot Study to demonstrate dredging and disposal alternatives for the site-specific conditions at New Bedford was a logical step in determining the engineering feasibility of these alternatives. Information from the Pilot Study added confidence to the assumptions made during the EFS and allowed for adjustments in engineering design prior to completion of the USEPA feasibility study.

74. The EFS developed conceptual design options for the dredging and CDF alternative and for the dredging and CAD alternative which are implementable for the Upper Estuary portion of the New Bedford Superfund Site. The effectiveness, cost, public acceptability, and other factors for each of these alternatives should be comparatively evaluated along with other alternatives being considered by the USEPA.

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